ASSESSMENT OF LOAD AND ENERGY REDUCTION TECHNIQUES (ALERT)

This is Section 2b of the ALERT Book, which provides guidance for teams conducting energy use assessments at federal sites as part of the Assessment of Load and Energy Reduction Techniques (ALERT) Program.

The ALERT Book is published in five sections:

ALERT Book, Section 1. http://www.eren.doe.gov/femp/techassist/pdf/alertbook_1.pdf
ALERT Book, Section 2a. http://www.eren.doe.gov/femp/techassist/pdf/alertbook_2a.pdf
ALERT Book, Section 2b. http://www.eren.doe.gov/femp/techassist/pdf/alertbook_2b.pdf
ALERT Book, Section 2c. http://www.eren.doe.gov/femp/techassist/pdf/alertbook_2c.pdf
ALERT Book, Section 3. http://www.eren.doe.gov/femp/techassist/pdf/alertbook_3.pdf

Economizer Troubleshooting Protocol

ALERT Be Energy Smart

Introduction

Air-side economizers are control devices that open and close dampers to bring in outside air for cooling and ventilation. They save energy by using outside air for cooling when the outdoor air is cooler than the return air. Unfortunately, improper operation of economizers is quite common and often goes unnoticed, resulting in increased energy use. This document describes a relatively simple procedure used to assess an economizer's performance.

Economizers are required by Title 24, Section 144(e) 1 for cooling fans with a capacity over 2,500 CFM and a cooling capacity over 75,000 Btu/hr.

Equipment Needed

- 4 Hobo XT (or Stowaway XT) dataloggers
- 1 HOBO software and communication cable

Note: When measuring air temperatures, sensor tips must be shielded from sources of radiation such as the sun or cooling coils. Is a sensor able to "see" the source of radiation? If it can, it should be shielded with a reflective material such as aluminum foil. The foil should not be in contact with the sensor, nor constrict air flow around it.

Procedure

Step 1

Launch the Hobo XT dataloggers. In most cases, we recommend configuring the loggers to operate for a period of two weeks. Make sure that the overwrite data box is selected (in the Hobo software) to ensure that you are collecting the most recent data.

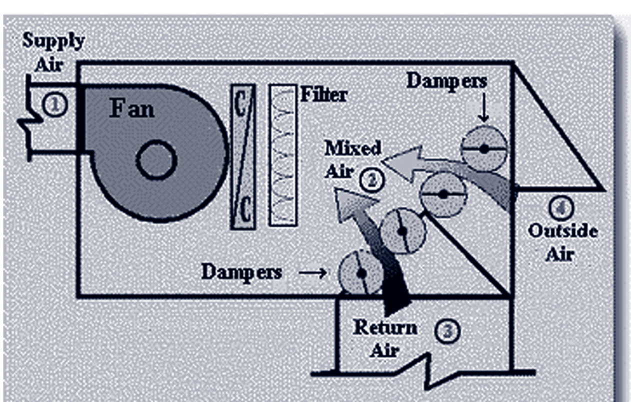

Figure 1. Diagram of a rooftop AC unit

Step 2

Place the Hobo XT thermistor tips in different air chambers (Figure 1). The loggers should be fastened securely with duct tape as the air at high speeds within the unit can lift the loggers away. Insure that the thermistor is suspended in the air chamber and not touching heating/cooling coil or other surfaces. If you are conducting long-term studies, consider securing the logger in such a way that provides easy access to the cable port.

Supply Air Temperature (1). Place a HOBO downstream of the cooling coil.

Mixed Air Temperature (2). Place a logger in the mixed air stream. It is important that the sensor is in a well-mixed location as far downstream from the mixing dampers as possible without being too close to the cooling coil.

Return Air Temperature (3). Place a HOBO in the return air upstream of the mixed air dampers.

Outside Air Temperature (4). Place a logger in a protected location near the outside air grill. Avoid a location where the sensor will receive direct sun. If you cannot find an ideal location, shield the sensor with aluminum foil to block direct sun allowing air to flow around the sensor while making no contact with it.

Step 3

After the data collection period has expired, retrieve the loggers from the field and download the data.

Step 4

Transfer data to a spreadsheet with the time for each sensor coincident. Graph all four data series on one chart to assess performance. The Energy Center developed a spreadsheet automating the graphing processes.

Looking at the Data

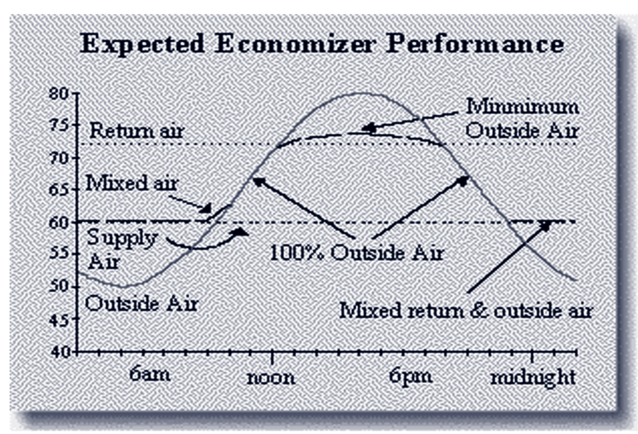

Figure 2. Graph of ideal economizer operation

The mixed air temperature and the outside air temperature should track closely when the outside air temperature is above the minimum supply air setpoint. This condition should persist until either; a) the outside air temperature exceeds the return air temperature, or b) the outside air temperature is below the minimum supply air temperature setpoint. Under these conditions the percentage of outside air brought in is reduced and the mixed air temperature and supply air temperature drift apart. For ventilation purposes, the outside air is never reduced to 0%.

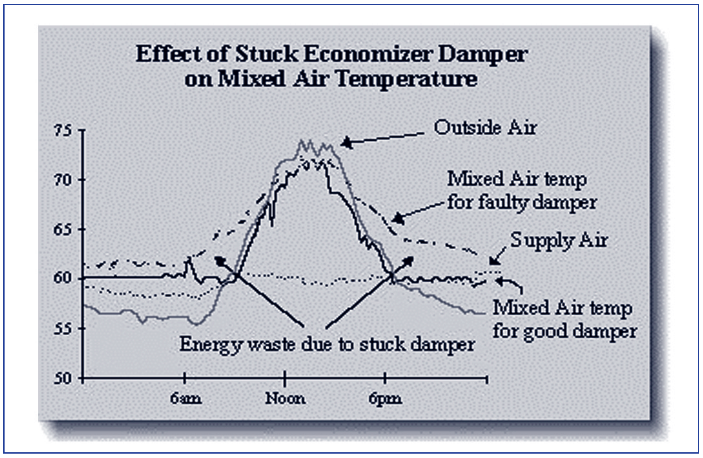

Figure 3. Typical data from an economizer with a stuck damper

Figure 3 shows that the mixed air temperature is not tracking outside air temperature even though the outside air is cooler than the return air. The most likely scenario is that the outside air damper is stuck in a closed or nearly closed position. If the damper was stuck open we would expect to see the mixed air temperature track outside air even when the outside air temperature is hotter than the return air or cooler than the supply air setpoint.

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Special thanks to Pacific Gas and Electric Company, a subsidiary of PG&E Corporation.

For more information on ALERT go to:
www.eren.doe.gov/femp/resources/dir_assessment.html
FEMP Help Desk: 800-DOE-EREC (363-3732) • *www.eren.doe.gov/femp*

Produced for the U.S. Department of Energy (DOE) by the National Renewable Energy Laboratory, a DOE national laboratory.
DOE/GO-102001-1455 • December 2001

Sample Instruments

- **Infrared (IR) Gun**
  - surface temperature measurement
- **Watt Meter**
  - simple power demand and consumption measurement
- **Ballast Detector**
  - magnetic or electronic
- **Light Meter**
  - light level readings
- **Window Coating Detector**
  - indicates low-e coating on which surface

ALERT Protocols/Checklists for Retuning HVAC, Chillers, Economizers, and Boilers

Draft 3/5/02 PNNL-JCH

HVAC: pages 1-10

Boiler: pages 11+

Information on the Building and HVAC system

Buildings address: ____

Point of Contact for Building: Mr. ____

Phone number: ____

e-mail: ____

Total floor space of building: ____

Description of Building automation system: ____

BAS vendor: ______________________________ Name of Software: ______________________________
Version of software: ____

Weather at start of inspection. Temperature ________, Wind _________, Humidity ________, Raining ______
Comments: ____

Weather at end of inspection if changing from start. Temperature ________, Wind _________, Humidity ________, Raining ______
Comments: ____

Types of heating and cooling system used. Packaged heat pumps, Central heating, Central cooling, Local heat cooling plant in building, all electric, Etc. ____

Heating System Type: ______________________________

Packaged System	Built-up
No. of Systems:	No: of Boilers
Make and Size of Systems	Make and Size of Boilers
Economizer or Stack Reclaim	
Are systems on networked (Y/N)	

Cooling System Type: ________________________________

Packaged System	Built-up
No. of Systems	No. of Chillers
Make and Size of Systems	Make and Size of chillers:
Economizer or Stack Reclaim	
Are systems on networked (Y/N)	

Air handler systems: ________________________________Cooling only: Cooling and Heating:

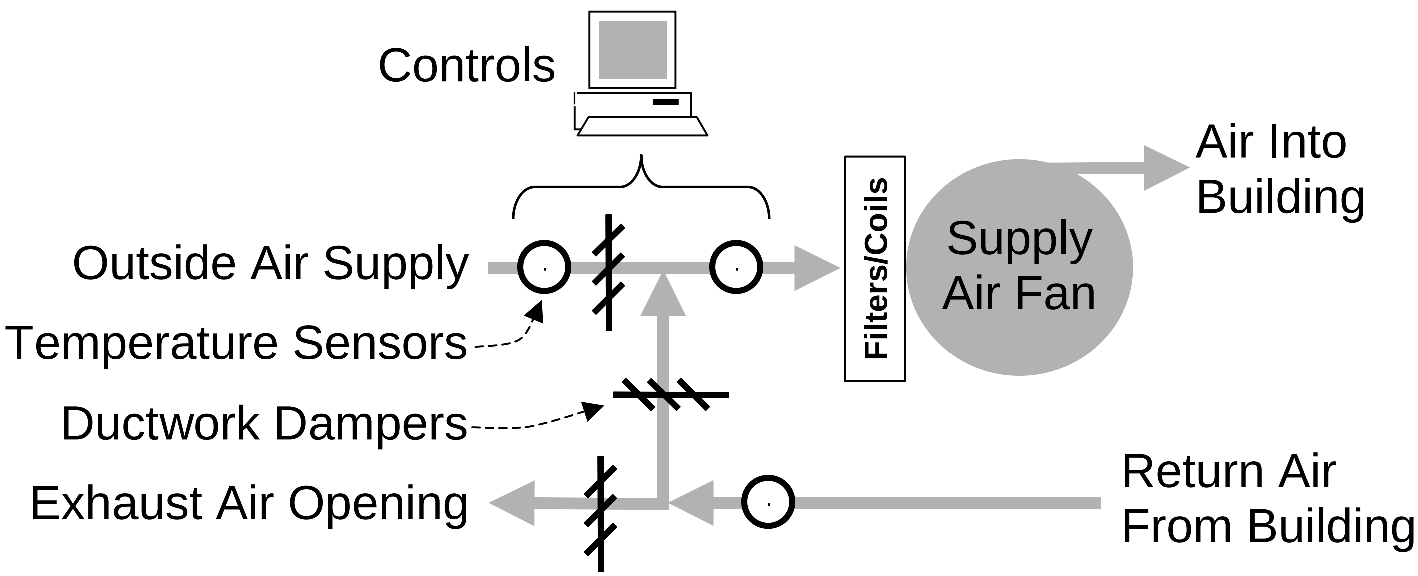
Packaged System	Built-up
No. of Systems:	No: of Chillers
Make and Size of Systems	Make and Size of Chillers
Economizer control:	No of AHU CFM or HP of AHU
Are systems networked (Y/N)	Economizer control:

Targets	Sub-targets	Check	Checking activity	Defaults or Recommendations	Current values, notes
Scheduling	Occupancy		What is the schedule Are systems shutting off during none use hours? Are systems coming on to early to warm up the building before staff arrive. If set for worst case winter condition the most of the time the building will be warm long before staff arrive. Use a reset schedule.		Weekdays Weekends Is the optimal start/stop and does it work or is there a reset schedule.
	janitorial		What is the schedule? Is too much lighting and equipment running for a small number of staff in building?		Weekdays Weekend
	Lighting		What is the lighting schedule? Check if lighting schedules are aligned with the occupancy schedules.		Weekdays Weekends
	Fan and AHU		What is the ventilation schedule? Supply, return, and exhaust fans? Check if schedules are aligned with the occupancy schedules.		Weekdays Weekends
	Plant		What is the heating/cooling plant schedule? Can the plant be shutdown or idled during none working hours? Check if plant schedules are aligned with the occupancy schedules. Are there opportunities to let the temperature coast in early evening?		Weekdays Weekends

Economizer		**Check to see that the economizer section is running at minimum fresh air settings.** Override BAS to minimum ODA. 1. Override ODA temp to high value 2. Override ODA damper setting to minimum 3. Look at damper position in BAS to see if it closes 4. if dampers may work and at what apparent position they may be		Is economizer active during warm-up. It should be off or closed during morning warm-up before staff arrives to work.
		Take following Air Temps to verify minimum mixed air. Check mixed air fraction by using temperatures of return, mixed and ODA. Fraction = Mix-Rtn/ODA-Rtn. If above 10% getting too much ODA. Lower minimum position. Note mixed air temperature set point does not play a part at this mode of operations so would not need to be checked unless mixed air temperature is below 40 degrees. Then limiting may be in effect.		Return air temp= ____________________ Mixed air temp = ____________________ Outdoor air temp = ___________________ OAF = ----------------------------------- = ________
		If ODA temperature is below 65 is economizer running in economizer mode. Check to see if dampers are modulating at mixed or leaving air set points or stuck.		Dampers modulating or stuck: ________________ Is economizer active when building is unoccupied.
Filters		Check filters, the dirtier the more fan power is required to pull air through them. Pressure is a cubed function on power. Normally runs less then ½ inch on larger clean filter systems.	Δp= 0.5”	Filter conditions: _________________________________
Coils		Check cooling and heating coils for clean air side passage. If plugged or dirty causes a 2 fold effect. Higher pressure losses and less heat transfer. A 47 degree chilled water coil inlet temperature should get you a less then 60 degree discharge air temp from the coil.		Coil conditions: ________________________________ _________________________________
Valves		Check cooling and heating valves for leakage by touching the piping inlet to the coil. If cooler then room or warmer then valve is leaking through. Touch leaving piping if there is a serious valve leakage problem and you should valve out the coil. You may need to valve out the effected coil until peak season is over. Primary concern is heating and cooling at same time.		Valves leaking _____________________
		Check cooling valve if 3 way to see if it fully closed on the bypass side if in full cooling mode. Normally is done by checking temperature of bypass loop and looking at valve steam position. Check heating valve is system is in heating mode.		Comments ______________________
Dual Duct systems		Dual Duct or Dual Deck check that heating section if fully off and cool. Check position of dampers and you will get an idea of the zone cooling needs. If most or all zones are calling for full cooling then you need to walk down some zones to see at what temperature they are running. Basically looking for zone that are heating or cooling more then required due to bad dampers or controls at the zone.		Zones not at set points ______________ Total number of zones ______________

Discharge Air		Check fan for running at 100% of speed or vortex dampers. If at 100% then may be working to hard. Check discharge pressure. If above 1.5 inches ask yourself why. Do we really need this much pressure? If at 3 to 4” then you probably are too high. Try a lower setting and see what areas start to complain and why.		Check discharge temp = ________________________ Check discharge pressure = _____________________
		Check discharge temperature. Can be from 45 to 100. If below 60 then may be to low. Extra heat may be added that is not required. Air only needs to be cool enough to cool the warmest areas it handles. Ask if they have staff complaining of sore necks or cold drafts. Do people have paper over the diffuser to direct the air away from them. This is a sign of to cold of air and maybe low flows. If discharge temps are above 65 and chillers or cooling is operational discharge may be to warm and could use to be lowered. Discharge temps are a critical balance point for the buildings current condition and thus can be changed to match building needs and minimize energy use. <u>Recommend</u>: design of reset algorithm for supply air temperature	> 55F- < 70F	Is discharge to high or low for Outdoor conditions causing heating and cooling at the same time or a building with to many zones not at set point. Is there a reset schedule and if so what are the settings. Does it appear the rest schedule matches building true needs.

Economizer components diagram:



Cooling If cooling running		Check if condenser coils are dirty		Status of condenser coils: _________________________
		Air-cooled condensers saturation temps should be within 20 to max of 30 degrees of ODA temps. Water-cooled system should be within 10 to no more then 15 degrees. Centrifugals should be at about 10 degrees. All tower or condenser fans should be running above about 80 ODA.		Check condenser saturation pressure: _______________ Derive condenser saturation temp: _________________ Determine approach = cond. Sat temp – ODA
		Cooling sides and water chillers should be within 10 degrees of saturation temps or no lower the 40 degrees for DX style systems .		
Water tower		Check water tower fill Above 80 F ODA all fans should be running		Water tower fill cond.: _____________________________ ODA at which all tower fans are running: ____________
Chillers		On centrifugals check if at 100% FLA and if so is the vane operator still in a modulating mode. If fully open machine is probably low charged.		
Chilled water temp		Check water tower fill conditions Check chilled water temperature set point. Why is it down below 50? Can the system run at 47 or does it really require 42 and if so what is the true driver. This is the one setting that normally gets pushed down just because.	47-55	saturation pressure in evap.= ______________________ derive saturation temp in evap. = __________________ Determine approach = cond. Sat. temp - water tower exit.
Condenser		Condenser water temperature set points should be as low as the machines can handle. This maybe as low as 60 for some newer machines and 80 for older ones that have R-12 in them.	60- 80F	
Pumps		Water pumping systems check for bypass loops partially open bypassing some water. These should be closed anytime the system is at 50% or higher load. If there are 3 way valves at the air handlers then they should not be used or not installed.		
		Check for more then 1 pump running on the same loop. Parallel pumping may not be required.		
Dehumidi fy.		Are we dehumidifying? Under 50% humidity may not be a realistic goal due to energy needs.		

Heating Side: Type of heating systems ___________________________________

Heating		Check if heat exchangers coils are dirty		Status of coils: ______________________
		Gas fired: Check flame for clean burning and quality. Flame should be bluish with yellow tips for efficient burning.		Flame visual appearance.
		Electric fired: Check control box for wiring conditions. If wires burnt and not repaired then system is not at capacity. .		
Water Boilers		Water temperature set points should be as low as the air handlers and heating sections can handle. This can be as low as 80 degrees for some conditions.	80-180F	Heating water temperature:_________________
Pumps		Water pumping systems check for bypass loops partially open bypassing some water. These should be closed anytime the system is at 50% or higher load. If there are 3 way valves at the air handlers then they should not be used or not installed.		
Reset Schedule		Check for the temperature settings of the hot water reset schedule. Normal schedule might be 80 at 70 outside temperature and 180 at 0 degrees outside.		Reset schedule exist: ____________ Schedule temps: ____________________
Dehumidi fication		Is the building dehumidifying in heating modes? Under 50% humidity may not be a realistic goal due to energy needs.		

Heating Side: Heat pumps ___________________________________

Heating		Check if heat exchangers coils are dirty Inside and outside coils		Status of coils: ______________________
		Check outdoor coil condition during heating mode. Coil should show even distribution of frost of moisture depending on ODA temperatures. Frost should not be heavy enough to block air flow unless fog or some other high moisture condition currently exist. Visually check for defrosting by observing moisture under unit. Should be wet as if water has been running off coils.		Coil visual condition for frost.: _____________ Frost pattern even. _____________ Defrosting. _____________________

		Check indoor Temperature heat rise . Should be in the 18 to 25 degree range. If warmer then heat strips are probably on. Are they needed for this ODA condition or is the building warming up. After the building has been heated they should normally be off and above about 35 or 40 degrees outside they also should be off. If on to much heat pump is not heating building as normally designed. .	20F	Indoor coil temp rise. ____________ Strip heat off: ______________
				: ___________

Domestic Hot water Heat system _______________________________________

Domestic Water Heating		Gas fired. Check if heat exchangers are clean. Check flame for clean burning and amount of rust under burners. If large amounts of rust are present then heat exchanger is deteriorating and air flow may be restricted. Check temperature setting:	120F	Status of coils: ________________________ Temp. Settings ______________________
		Electric. Check temperature settings.	120F	Settings. ______________________
		Circulating pumps. Are pumps running and if so are they shut off during unoccupied mode. If temperature activated then is the setting down to a normal 100 degrees. .	100F	Pumps Active: ______________ Sequenced with occupancy:___________ Temperature set points. ___________

Other Load Reduction and Energy Savings Opportunities:

Utility data		Ask for energy meter data to understand load profile		
Load reduction		Load role within a facility. Cycle air handlers off for 30 minutes at a time or at least the cooling off.		
		Turn off hall lights Take every second light bulb out of fixture		
		Turn off parking lot lights away form the building and have people move their cars closer who are working late.		
		Allow for alternate work schedules with additional shift Instead of 9am – 5pm suggest 2 shifts		
		Reset zone temperatures during peak times Use pre-cooling strategies draw bldg down at night and let is coast during peak..		
		Never run 2 chillers at part load when one machine can carry it even if the chilled water temp slips a little.		
		Always turn off computers when not in use.		
		Put a timer on all electric hot water tanks and turn them off during all the peak time windows. Storage can normally carry you through.		
		Check if all of the staff's lunch refrigerators are being used. Unplug those that are lightly used and consolidate.		
		Put timer on office water coolers. Generally, there is significant storage to carry sufficient cold water through major portion of the peak period.		
		Has lighting system upgrades been performed?		All areas or just in some:

CHECKLIST FOR BOILER TUNING

REFERENCES:
1. Boiler Efficiency Improvement
2. CEM Training Course section P

Information on the Building and Boiler system

Buildings address: ____

Point of Contact for Building: ____

Phone number: ____
e-mail: ____

Description of Boiler automation system:

Control System Function: Maintain output of boiler (pressure or temperature) or Maintain combustion (i.e. air/fuel mixture)(O/C)?
Explain the type of System (i.e. lead-lag, O_2 trim, etc.): __________________________________
Networked System(s) (Y/N): ______________________________

Boiler System	**Cost Structure**
No. of Boilers: Mfg./Type Yr Built Rated Output(lb/h,psig) FuelType(#)[1]	Annual Utility Costs or Average Unit Cost (units of usage): 1. Natural gas ______________________ 2. Fuel Oil ______________________ 3. Electricity ______________________ 4. Compressed air ______________________ 5. Other ______________________
Auxiliary Equipment (Y/N) (i.e.steam seperator,economizer,air-preheater, heat exchanger(s)): Mfg./Type Date Built, Rated Output	Annual Utility Usage: (Consumables): 1. Natural gas ______________________ 2. Fuel Oil ______________________ 3. Electricity ______________________ 4. Compressed air ______________________ 5. Other ______________________

[1] List all fuel types that can be burned in the boiler, use numbers of cost structure section as applicable

Water Treatment (Y/ N) Mfg./Type of Boiler(s), Date Built, Rated Output	Burner type/mfg.: (i.e. low No_x, Ring, steam/air atomized etc.) .
Boiler Blowdowns performed (Y/N) Automatic, Manual or Continuous (A/ M/ C) ? Frequency of blowdowns (Hrly, Daily, as needed)_____________	Condensate return to boiler plant (Y/N) Quantify annual (or average or %) __________________ gallons Temp and/or source. of return water __________________
Leaks in steam/water piping (Y/N) Qty (i.e. size,psig, temp.,etc.) ___________________________	Insulation missing steam/hot water piping or tanks (Y/ N) Explain (i.e.amt missing.pipe dia.,psig, Temp.,etc.) ______________________________________
Steam traps (Y/ N) Number of steam traps ________________	Steam traps audited (Y/ N) Frequency of audits (daily, qrtly, annually etc.)
Emission problems in the plant? (Y/N)	Type of emission problems (S_O,No_x, particulates etc.), how identified (monitoring?), looking for burner problems or misadjustment.
Boiler Types circle all that apply: • Forced draft (Y/N) • Induced draft (Y/N) • Natural draft (Y/N)	Number of stack(s) for the boiler (i.e. one per boiler, one combined for all boilers etc.), neutral, positive or negative design Approximate height of the stack(s) – design draft in boiler
Boiler Demand Loads: Number, type and square footage of each building that receives steam/water from boiler plant? (Ideally want energy per square foot per building)	Boiler Demand Loads: Variable/Constant (V/C) Explain (i.e. daily or seasonal variations):

Tests of Boiler System: ______________

Boiler Stack Gases		**Check Combustion Efficiency at high fire with Bacharach:** 5. Temperature of stack gases ____°F 6. Ambient temperature ______°F 7. Percent oxygen in the stack 8. Combustion efficiency reading ________ %	goal > 75%	• Follow Bacharach recommended test procedures, and note location of test sample point (i.e. before or after induced draft fan, after damper, top of stack) Provide simple drawing.
		Check Combustion Efficiency at low fire with Bacharach: 1. Temperature of stack gases ____ °F 2. Ambient temperature ____°F 3. Percent oxygen in the stack 4. Combustion efficiency reading ________%	goal > 60%	• Follow Bacharach recommended test procedures, and note location of test sample point (i.e. before or after induced draft fan, after damper, top of stack Provide simple drawing.
Feedwater Input, Fuel Input & Steam or Water Output		**Check Thermal Efficiency at high fire by noting**: 1. Temperature of feedwater ____°F 2. Feedwater flow rate _____gpm 3. Steam/water (Temperature or pressure if water or saturated steam, if superheated steam, need both parameters) ____°F 4. Fuel flow rate ____gpm 5. Fuel heating value (typically a constant-from utility/plant prior test.) ____ Btu/cu.ft., or Btu/gal For calculation sheet see Reference 1 Appendix. B & C.	goal > 72%	• If any other mass flow leaves or enters the boiler, the mass must be measured or eliminated (i.e. no blowdowns during the test run) • Direct measurements are preferred. • Feedwater temperature can be taken at feedwater storage tank. • Note location of measured readings or where the readings came from if not directly measured. • Provide simple drawing.
Air System		**Check Dampers:** The damper should move easily, show no signs of getting stuck open or closed, and follow the controls smoothly		Look for wear or deformed linkage – lubrication?
Boiler		**Check Burner Flame for:** 1. Shape 2. Color 3. Uniformity		Want the shape to be uniform shape that matches the type of burner (i.e. a ring burner should have ring shape, if not part of burner may be plugged). The color indicates whether burning to rich or not. Good color would be Blue with yellow tips. Is the shape ragged at the edges or flickering up and down

		Check Blowdown Controls: Check that the blowdown valve is not leaking by in the closed position. Manual or automatic blowdown should not be excessive. The blowdown need only be enough to eliminate solids from the blowdown boiler. If a blowdown is performed by while you are testing, check the blowdown water for solids.		
Boiler		**Check firebox temperature (exterior boiler walls)**	< 150 F	
Boiler Drum		**Check Water Level :** Check that the water level in the boiler is not above high water mark or below low-level mark. Also, watch as boiler operates that the level is not fluctuating significantly.		
Plant auxiliary equipment		**Check vibration of aux. Equipment in the plant (i.e. fans, pumps etc):**		
		Check temperature of aux. Equipment in the plant (i.e. fans, pumps etc):		Thermography may be used
Plant auxiliary equipment		**Check current draw of aux. equipment**		Attention to hot equipment
Plant auxiliary equipment		**Check for air leaks at the boiler or throughout the plant.** In the boiler you are looking for infiltration points. Throughout the plant you may find compressed air leaks. These may be easy to hear and trace back to the source.		Thermography may be used
		Check for steam use throughout the plant for possible substitution (i.e. if steam tracing is used to reduce freezing in more than 15 places it may be more economical to use a glycol solution)		(design recommendations)
		Check for heat recovery opportunities Look for any sources of heat going to the sewer or air. Measure temperature and flow if possible of any source going to the sewer or air that may be able to be captured and used.		Note (if can be determined) the chemical composition of the hot medium that is being dumped to the sewer or air (design recommendations)
		Check steam traps in the plant: If steam is in the pipe, a small stream may be okay, but a large stream of steam leaving the trap is typically a malfunctioning trap. Take temperature upstream and downstream of the trap		• Note the type of trap used at the location • Note the medium that the trap is working on (i.e. condensate or steam at a given pressure, if known) • Acoustic trap tester may also be used to check whether the trap is working

		Check feed and boiler water Check the water at several points throughout the feed water system. Check the make-up water that enters the system. Check a boiler water sample. Recommended limits are presented in Reference 2.		• Water kits can be used (ph, hardness, traces of chemicals used in the treatment or brought in with the make-up water should be identified. (If necessary, a sample may have to be analyzed at a lab)

- Boiler Metrics
  - Low Combustion efficiency (< 75%)
    - Excess air (> 20% or >5% O_2)
      - O_2 Trim
      - Damper tuning
    - Stack Hi Temp (T>400 °F)
      - See excess air
      - Tube fouling
    - Low Ambient Temperature (T< 90°F)
      - Air preheater
      - Air intake relocation
    - Fuel-Air Mixing (clean/replace nozzle)
  - Low Thermal Efficiency (ç< 72%)
    - Low combustion efficiency (<75%)
    - High Firebox heat loss ($T_{exterior}$> 150 F)
    - Steam leaks
    - Boiler scaling

USE PROFILE

Site:
Fuel Type:
No. Units:
~ Annual $
- Fuel
- O&M
- Capital

PERFORMANCE PROFILE

Fuel $/ft^2$
Combust Eff:
Thermal Eff:
Therms
- space heat
- hot water
Condensate Return (%)
Fuel Cost:

CHECK LIST

Boiler Type:
Economizer?
FW demin?
Control System
- O_2 trim?
- lead-lag?
- Low fire %
Stack Temp @
- high fire
– low fire
Flame
- shape
- color
- uniformity
IR Survey
O_2 @
- high fire
- low fire
Instrument Cal

CONDITION NOTES

Housekeeping:
Leakage:
Insulation:
Vibe/Temp:
Acoustic:

INFRASTRUCTURE PROFILE

Operations:
Maintenance:
Engineering:
Training:
Administration:

Lighting Protocol

Introduction

The most effective way to reduce lighting energy consumption is to turn lights off when they are not needed. This application note outlines the necessary equipment and procedure for conducting a simple lighting study using recorded light levels as a proxy for a fixture's "on" or "off" status. The information from such a study is used to establish a baseline operating pattern. The information will help answer the following basic questions:

- When are the lights on?
- What is the cost associated with the current operating schedule?
- Does the current operating schedule leave opportunities for saving energy with lighting controls?

Equipment Needed

- 1 Hobo Light logger for each lighting circuit to be monitored
- 1 Hobo software and cable for connection to computer

Procedure

1. Launch the Hobo Light data loggers and configure the logger to operate for two weeks.

2. Select one representative fixture in each circuit or lighting zone you will be monitoring. Place the logger in or near that fixture, close to and facing the lamp. Place the logger so that light from the lamp will be significantly higher than ambient light. If placed inside the fixture, do not allow the logger to come in direct contact with the lamp or other hot surfaces.

3. At the end of the study period, retrieve the loggers, download and analyze the data. The Pacific Gas and Electric Energy Center has developed an automated Microsoft Excel spreadsheet to assist in downloading and analyzing lighting data from Hobo data loggers. They have also written an application note describing its capabilities and use.

It was noticed that there was a 10-20% variation in the absolute light level reported by these loggers; however, they do reliably indicate whether a light is "on" or "off". In Figure 1, the light use pattern is very clearly depicted. Note that the light levels vary from around 38 to 43. This is due to the resolution of the loggers. It is safe to say that any light reading above 35 means that the lights are on. The lighting threshold is then 35.

4. Total the number of run-hours for each fixture or circuit. This is done by adding the total number of readings that register a "lights on" status and multiplying by the data collection interval. For example, 400 "lights on" readings with a five-minute interval is equivalent to 2000 minutes or 33 hours and 20 minutes of runtime.

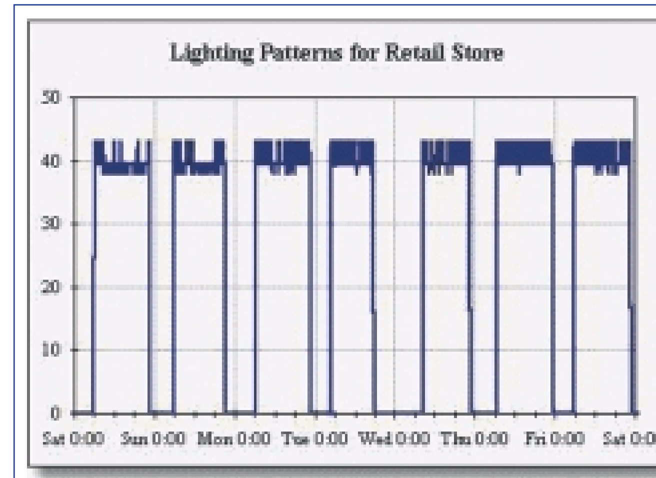


Figure 1. Graph of lighting patterns for one week

To calculate energy use, multiply the hours of use by the watts/fixture (dependent on lamp type, ballast type, and number of lamps per fixture) and the number of fixtures.

watt hours = hours of use x watts/fixture x number of fixtures

Note: When evaluating dimming systems, you must be able to distinguish between the electric and daylight contribution to light levels. The closer the logger is placed to the electric light source, the easier it will be to distinguish the dimmed electric lighting and ambient daylight.

Lighting Analysis Worksheet

Installing occupancy sensors and time controls to operate lighting systems can often be a wise investment. With the appropriate tools and knowledge, justifying their installation or checking their operation is a relatively simple task. In addition to the necessary equipment for conducting these types of studies, the Pacific Gas and Electric Energy Center Tool Lending Library makes available a Microsoft Excel spreadsheet to assist in importing and analyzing data to help answer the following questions:

- What are the potential savings associated with a specific time schedule?
- Are the lights on when no one is in the room?
- Are the lights off when they are scheduled to be on?
- Are the lights on when they are scheduled to be off?

The spreadsheet is designed for use with data from Hobo data loggers, but can also be used as a stand-alone tool to determine potential savings from user-defined lighting schedules. It has automated functions that import and analyze lighting operation and occupancy data. The subroutines have been written to analyze the data and generate a modest report based on eight days' data. This time period is easily extended for longer studies.

Lighting operation data is collected using a Hobo Light and occupancy data is collected by using a modified infrared motion sensor with a Hobo Volt.

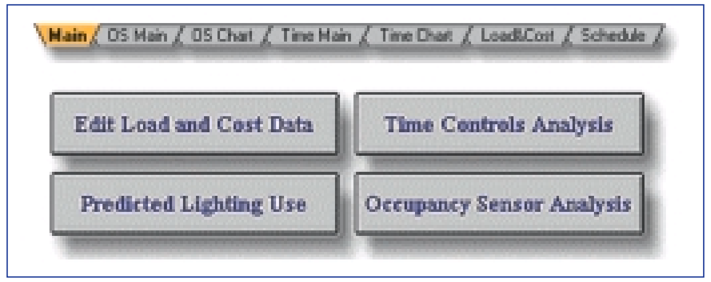


Figure 2. Introductory screen for Lighting Analysis spreadsheet

The spreadsheet will open to the Main screen. Begin by entering information about the lighting system's wattage and local utility rates. Go to this worksheet by clicking on the "Load & Cost" tab at the bottom of the screen or by clicking on the "Edit Load and Cost Data" button. You can jump to the related descriptions in this web page by clicking on the buttons in Figure 2.

Load and Cost Data

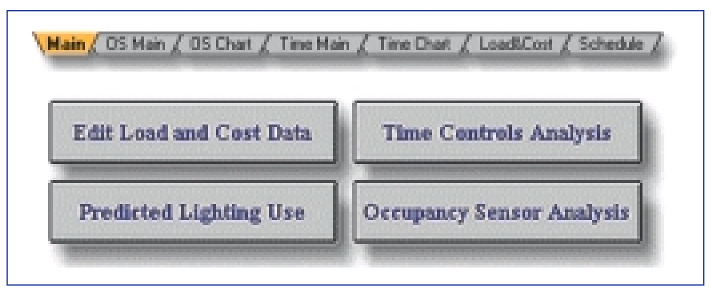


Figure 3. Screen for entering load and utility rates data

Here, you enter information on load and energy costs for up to three lighting systems (Groups 1, 2 and 3). This information will be used throughout the spreadsheet.

Evaluating the Operation of Existing Lighting Controls

The spreadsheet has a time control schedule allowing you to input the percentage of lights that are on in any given hour of the day. To change the values in the table, highlight the cell or cells and use the up/down

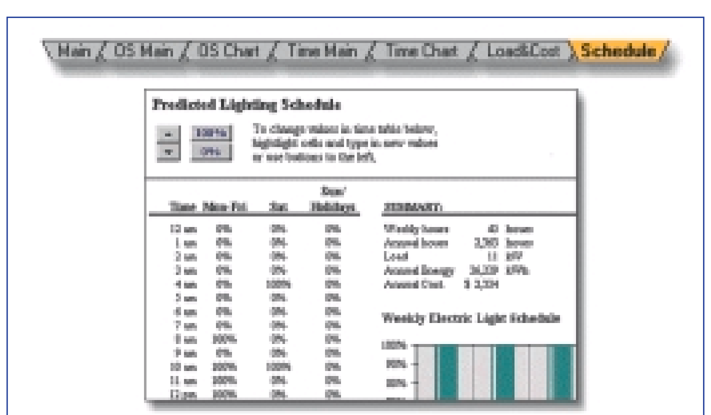


Figure 4. User-defined lighting schedule screen

arrow buttons to increment the highlighted values by 5% per click or click on the 0% or 100% buttons to insert those values. Days are categorized into weekdays (Monday through Friday), Saturdays, and Sundays/holidays. After defining the schedule, the spreadsheet will calculate the weekly and annual hours of operation.

Exploring Potential Savings for Time Controls

From the Main Menu click on "Time Control Analysis" or click on the "Time Main" tab at the bottom of the screen.

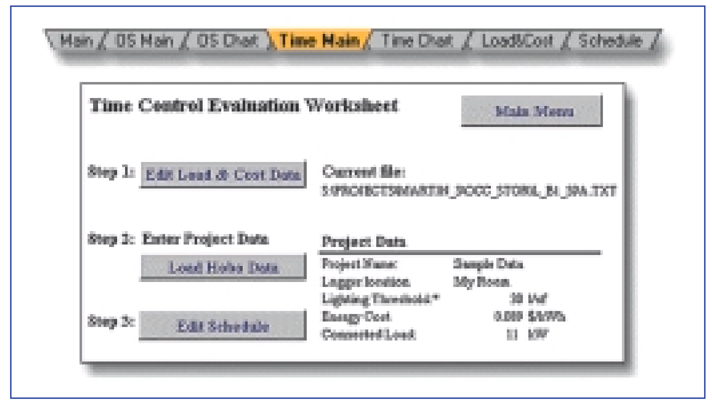


Figure 5. Time Controls screen

The spreadsheet can also be used to evaluate a space's lighting operation patterns based on data from a Hobo Light data logger. The individual worksheets within the spreadsheet are designed to walk you through the procedure. Simply follow the steps from top to bottom.

By clicking the "Load Hobo Data" button, the spreadsheet will prompt you to select the file containing the data from the Hobo Light data logger. Find that file and click on "OK." It will then update the graph showing the operation of the lights over the monitoring period. With this information, you can compare the measured operation of the lighting system to its operation if time controls are used. Or you can compare it to the existing schedule if you entered that schedule into the Predicted Lighting Schedule.

Exploring Potential Savings for Occupancy Sensors

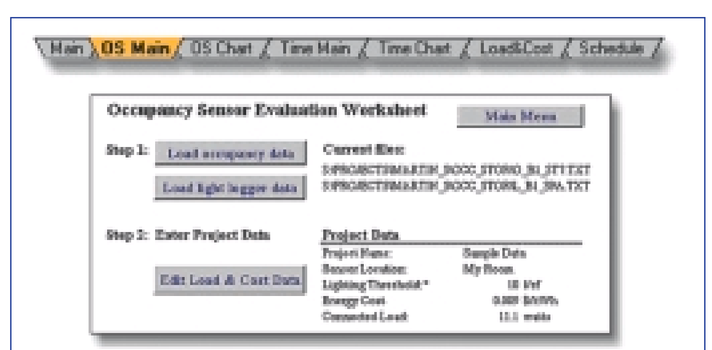


Figure 6. Screen for entering occupancy sensor information

To evaluate potential savings, you will need to import the light-use data from the Hobo Light and occupancy data from the Hobo Volt. With this coincident data, the spreadsheet will generate information about potential savings if an occupancy sensor was installed in the test space. Another automatically generated graph shows the unoccupied periods when the lights could have been turned off. The spreadsheet calculates potential savings for that week and estimates annual savings.

Graph of Actual Light-Use Patterns versus Scheduled Light-Use Patterns

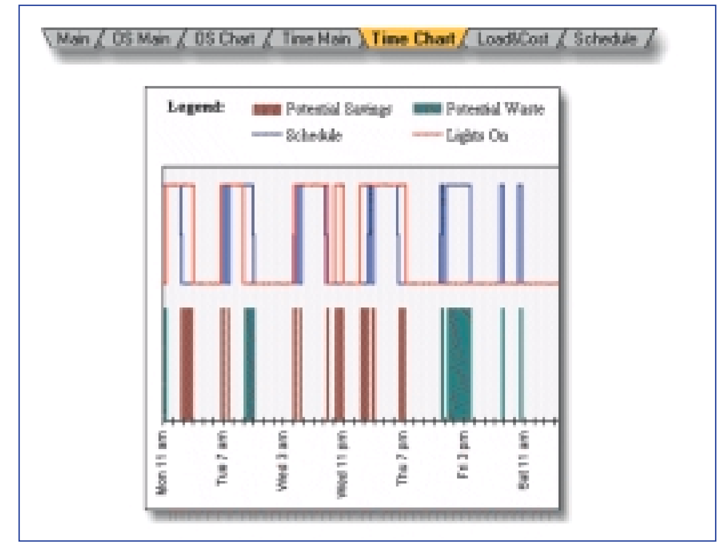


Figure 7. Graph of measured light versus scheduled light in system operation

In Figure 7, the top graph plots the user-defined lighting schedule against the lights' measured run time from Hobo data. The bottom graph identifies potential waste and savings based on a simple comparison of the Hobo data. For example, if the lights are off during times when they have been programmed to be on, the schedule can be changed to save energy. This is labeled as potential waste. Potential savings identify when lights are on during hours when the lights are scheduled to be off. In this case, reducing the use of space during unscheduled hours saves energy.

Graph of Actual Light-Use Patterns versus Scheduled Light-Use Patterns

Figure 8. Graph of occupancy patterns versus light use patterns

Similar to the previous graph, this graph compares two variables. The graph in Figure 8 plots measured light use patterns versus occupancy patterns and helps to answer the following questions:

- Are the lights on when no one is in the room?
- What, if any, are the potential savings if an occupancy sensor controlled the lights in the space?

The information in this publication was provided by Pacific Gas & Electric Company (PG&E). Visit the PG&E Web site at *www.pge.com*

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Produced for the U.S. Department of Energy (DOE) by the National Renewable Energy Laboratory, a DOE national laboratory.
DOE/GO-102001-1499 • December 2001

INFRARED SURVEY PROTOCOL

The following IR protocol assumes the individual performing the IR survey activity is knowledgeable of this technology to a level commensurate with recommendations by ANST for Level I certification.

IR survey opportunities and needs will change depending on facility design. Use the following survey suggestions as applicable for site under examination. If IR anomaly found, fill out information as applicable using "IR Anomaly Data Sheet", Addendum "A".

Boilers		1. Survey fire box for evidence of refractory deterioration. 2. Survey boiler for evidence of air inleakage or exhaust. 3. Survey blowdown lines, relief valves, drain isolations and other possible system penetrations for evidence of improper heat loss/leakage.		• If anomaly found, complete information as defined on "IR Anomaly Data Sheet", Addendum "A"
Steam Systems		1. Survey system drains/blowdown lines for system heat loss. 2. Survey system steam traps for proper operation and evidence of excessive heat loss (ensure proper trap operation). 3. Survey System lines for evidence of inadequate insulation .		• If anomaly found, complete information as defined on "IR Anomaly Data Sheet", Addendum "A"
Hot Water Systems		1. Survey heat exchangers for proper operation and validation of installed instrumentation.		If anomaly found, complete information as defined on "IR Anomaly Data Sheet", Addendum "A"
Pumps /Motors		1. Survey for indication of alignment problems. 2. Survey for indication of bearing overheating 3. Survey for indication of motor overheating		If anomaly found, complete information as defined on "IR Anomaly Data Sheet", Addendum "A"
Building Envelope		1. Survey for evidence of air loss/inadequate insulation. 2. Survey roof if time of year and weather conditions conducive to survey needs, i.e. dry roof, clear sky, evening hours.		If anomaly found, complete information as defined on "IR Anomaly Data Sheet", Addendum "A"
Miscellaneous		1. Survey radiant floor heating for evidence of coil leakage/blockage 2. Survey heating and cooling coils at VAV boxes and similar system heat exchangers for evidence of simultaneous heating and cooling..		If anomaly found, complete information as defined on "IR Anomaly Data Sheet", Addendum "A"

IR Protocol
Addendum "A"

1.) Building # ___________________

2.) Room # _____________________

3.) Component/Equipment ID/Description:

____

4.) System Operating Condition, i.e. flow, temp, press, speed, as applicable. :

____

5.) Environment (as applicable to survey):
Indoors/Outdoors? ______________
Background Temp ______________
Wind Speed ______________
Time of Day ______________
Cloudy/Sunny ? ______________

6.) Area of interest surface condition, i.e., painted/polished chrome/greasy/rusted iron, etc.

____

7.) IR image # .______________

8.) Visible Light Image # (digital) _____________________

9.) IR Anomaly (suspected fault)
Description____
____
____
____
____